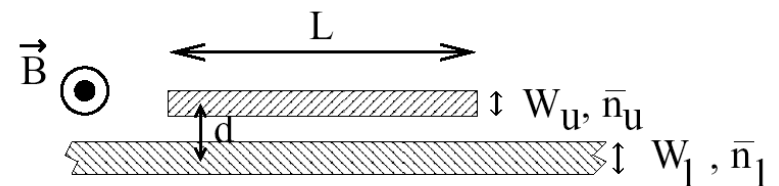


Electrons in a Short Quantum Wire

Bertrand Halperin, Harvard University, DMR-0233773

Physicists have observed **momentum-conserved tunneling** between **a pair of wires so narrow that electrons are confined to only one or two transverse quantum modes in each wire**. Results, as a function of source-drain voltage, perpendicular magnetic field, and electron density, **reveal features of the electron wavefunctions** that reflect **peculiar properties of one-dimensional interacting electron systems**, as well as details of the confining potential at the ends of the wire. Wires were fabricated in GaAs using the technique of cleaved-edge overgrowth.

In wires with a gate-controlled central region, there seems to be a **phase transition** when the density drops below 15 electrons per μm in the central region, to a state where the **central region is separated by barriers** from the rest of the wire, and the **number of electrons in it is quantized in integer values**.

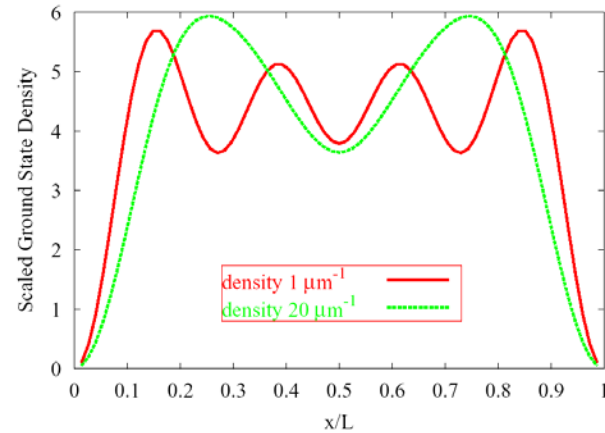


Schematic of wire pair

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Calculations. We have studied the states of one-dimensional wire segments containing a small number of interacting electrons, using a variety of analytic and numerical methods, and have calculated the tunneling amplitudes for successive electrons. Results show many features in common with the experiments, and support an interpretation that electrons in the low-density region form a fluctuating “Wigner” crystal, with greatly reduced energies for spin excitations.



Charge density in 4-electron wires. Low density wire shows four peaks due to strong interactions.

Education and outreach. The reported project and related ones have provided training for three graduate students at Harvard, as well as for two students visiting from the Weizmann Institute.